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EFFECTS OF PRESCRIBED FIRE ON MOVEMENTS OF FEMALE SAGE GROUSE FROM BREEDING TO SUMMER RANGES

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ABSTRACT.—We compared summer movement patterns of female Sage Grouse (*Centrocercus urophasianus*) in southeastern Idaho before (1987–1989) and after (1990–1992) a prescribed fire which removed vegetation cover, primarily Wyoming big sagebrush (*Artemisia tridentata wyomingensis*), from approximately 57% of a 5800 ha area. Grouse moved 1–69 km ($\bar{x}$ = 17.8 ± 2.0 km [SE]; N = 81) from breeding and nesting areas to summer ranges, predominantly in northwest or southwest directions during the 6-year period. There was no difference in timing, distance, or direction moved between birds captured in burned and unburned habitats. The data provided further evidence of traditional migration routes for Sage Grouse breeding and nesting in the Big Desert. *Received 16 Mar. 1996, accepted 1 Sept. 1996.*

Several species of Tetraoninae are migratory (Hoffman and Braun 1975, Herzog and Keppie 1980, Cade and Hoffman 1993, Schroeder and Braun 1993). Some Sage Grouse (*Centrocercus urophasianus*) populations are migratory when year-round habitat requirements cannot be met in proximal areas. Thus, some grouse seek suitable habitat in more than two seasonal-use areas that are often widely separated. Interseasonal movements of 20–81 km have been documented for Sage Grouse populations (Connelly and Markham 1983, Gates 1983, Berry and Eng 1985, Wakkinen 1990). The Big Desert sagebrush ecosystem in southeastern Idaho provides important Sage Grouse breeding, nesting, and brood-rearing habitat (Connelly et al. 1988, Wakkinen 1990). However, during dry summers, vegetation food sources become desiccated, and Sage Grouse migrate to more mesic summering areas (Connelly et al. 1988, Fischer et al. 1996). Grouse return to breeding range beginning in late fall, presumably to be near leks for the onset of breeding the following spring (Robertson 1991, Connelly et al. 1988).

Berry and Eng (1985) and Connelly et al. (1988) noted the importance of identifying Sage Grouse seasonal use areas and migration routes between or among these areas. Their research suggested that migratory Sage Grouse populations should be defined on a temporal and geographic basis

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and that all seasonal habitats and migration corridors should be managed accordingly. Habitat manipulation, such as sagebrush removal, has contributed to declining populations of Sage Grouse throughout their range (Autenrieth 1969, Klebenow 1970, Swenson et al. 1987, Braun 1995). Controlled burning has become an increasingly popular method of sagebrush removal on western rangelands (Frandsen 1985, Bunting et al. 1987). The influence of fire on Sage Grouse winter movements (Robertson 1991), breeding males (Benson et al. 1991), and brooding females and brood habitat (Martin 1990, Fischer et al. 1996) has been investigated, but little is known about the influence of fire on migration patterns (e.g., timing, use of traditional routes) during spring and summer. Sage Grouse returning to traditional leks (Dunn and Braun 1985) and specific nesting areas (Fischer et al. 1993) may find altered habitats unsuitable for breeding and/or nesting and, therefore, initiate migration earlier than individuals in unaltered habitats. Our objectives were to document direction and distance of summer movements and to identify summer ranges used by migrating female Sage Grouse. We tested the hypotheses that (1) Sage Grouse show no directional trend when moving from breeding and nesting ranges to summer ranges, and that (2) there are no differences in direction, timing, or distance of movement between breeding and nesting range and summer ranges, after prescribed fire for female Sage Grouse captured in unburned habitat and in or immediately adjacent to burned habitat.

STUDY AREA AND METHODS

We studied Sage Grouse from 1987 through 1992 on a 20,000-ha portion of the 240,867-ha Big Desert in Blaine and Butte counties on the Upper Snake River Plain, southeastern Idaho (43°24′N, 113°07′W). The topography varies from flat to gently undulating terrain with an interspersion of exposed silicic and basaltic volcanic outcrops and craters. Elevations ranged from 1536 m to 2304 m. Median precipitation during the study was 17.1 cm, which was below the long-term median of 24.0 cm (1956–89; data from Agric. Engineering Dept., Univ. Idaho). Hironaka et al. (1983) classified the Big Desert as a Wyoming big sagebrush/bluebunch wheatgrass (*Agropyron spicatum*) habitat type; threetip sagebrush (*A. tripartita*), rabbitbrush (*Chrysothamnus* spp.), Sandberg bluegrass (*Poa sandbergii*), and bottlebrush squirreltail (*Sitanion hystrix*) were abundant. As part of a larger study to investigate differences in ecology of Sage Grouse before and after fire (Fischer 1994), the Bureau of Land Management prescribed burned a 5800 ha portion of the northern half of the study area during late summer 1989. All portions of the study area were grazed by cattle, except for the burned area, which was ungrazed for one year prior to and two years following the burn. Wakkinen (1990) and Fischer (1994) provided detailed descriptions of the Big Desert study area.

Data collection.—Sage Grouse were captured by spotlighting at night (Giesen et al. 1982, Wakkinen et al. 1992) on and near leks during March and April 1987–1992. We captured 219 females and fitted them with solar- or battery-powered, poncho-mounted (Amstrup 1980) transmitters. The transmitter and poncho weighed approximately 20 g, which was ≤2% of female body weights. We classified females as either treatment or control based upon whether they were captured on leks in (N = 5) or within one km (N = 7) of the burn or ≥3.5 km south of the burn (N = 18), respectively. Females on leks within one km of the burn were considered treatment females because fire removed potential nesting habitat for these birds (females on the study area moved 3.4 ± 0.4 km [SE] from lek-of-capture to nest [Fischer 1994]). The distance of the next closest active lek to the burn was 3.5 km, and none of the females from this or any other control lek nested within the burn.

We used radiotelemetry to identify timing, distance, and direction of movements to summer ranges. Following the breeding and nesting seasons, we attempted to locate radiomarked grouse at least once every two weeks using ground and aerial searches. However, because the birds occupied an area over 4000 km^2 during summer, it was not possible to search thoroughly all potential summer ranges during each flight. Thus, we did not locate all radiomarked birds every two weeks. Due to the wide distribution of birds, 46% of locations after 15 June were from fixed-wing aircraft, compared to 26% prior to 15 June. Median error for aerial locations of six transmitters placed at fixed locations was 294.9 m. We plotted each location on 7.5-min topographic maps using the Universal Transverse Mercator grid system. Location data were partitioned into two-week intervals starting on 1 May and continuing through 30 July. The final interval included all locations between 1 August and 30 September, because of smaller sample sizes due to a reduction in flight frequency after birds had moved to summer ranges. Within intervals, we assigned each location to appropriate 90° quadrants (Northeast Q-I = 0–90°; Southeast Q-II = 90–180°; Southwest Q-III = 180-270°; Northwest Q-IV = 270–360°). Quadrants were centered on the lek-of-capture for non-nesting females or females whose nesting attempts could not be identified (see Connelly et al. 1993), whereas the nest was used as the point-of-origin for nesting females.

We calculated straight-line distance from the point of origin to all subsequent locations of each female during and after the nesting season. We arbitrarily decided that migration was initiated when a female had moved ≥5 km from her respective point of origin because mean lek-to-nest distance for female Sage Grouse in the study area was 3.44 km (Fischer 1994) and 76% of females nested within 5 km of lek of capture. Within each time interval, we calculated the farthest distance moved from point-of-origin for each individual and percentage of birds that were ≥5 km from point of origin. Because the number of radio locations after 1 August was limited, the last distance recorded for all individuals located after 15 June represented the minimum straight-line distance of summer movements.

Data analysis.—We separated data into preburn (1987–1989) and postburn (1990–1992) periods and used separate Chi-square tests (Zar 1984) on each data set (treatment and control pooled) to test for homogeneity of locations among the four quadrants within each time interval. Preburn data were then partitioned into females captured on treatment or control leks, and the two data sets were analyzed separately with Chi-square tests to identify any differences in direction of migration from the two areas prior to the fire. Postburn treatment and control data were analyzed in the same manner. We then pooled all data (1987–1992) to investigate whether fire influenced summer migration patterns of females captured on treatment leks, and used a Cochran-Mantel-Haentzel (CMH) statistic (SAS 1988) on the following four variables: Q (Quadrants I-IV), I (2-week time intervals; 1–7), P (before fire, after fire), and Area (treatment, control). The CMH statistic, an *n*-way cross-tabulation contingency table, tested the relationship between counts of treatment and control females in quadrants before and after fire, after adjusting for the possible confounding effects of I and Q (SAS 1988).

We used analysis of variance (ANOVA) on ranks (Conover and Iman 1981) of postburn intervals (1–7) to examine if grouse from treatment and control areas initiated migration at the same time. We also used ANOVA on log-transformed migration distances recorded after

15 June 1990–1992 to detect differences in distances moved by females from treatment and control leks.

RESULTS

We captured 112 females (51 preburn; 61 postburn) on treatment leks and 107 females (47 preburn; 60 postburn) on control leks. Preburn data indicated no differences in quadrant use until July, when grouse moved southwest more frequently than expected. Postburn data indicated grouse moved northwest and southwest proportionately more than expected after June (Table 1). When preburn treatment and control data were analyzed separately, control females moved southwest (Table 2) and treatment females moved southwest and northwest more than expected after June (Table 3). The postburn control and treatment data also indicated more birds moved in southwest and northwest directions (Tables 2 and 3). When all six years of data were pooled, there was a significant Area × P interaction (CMH General Association test statistic = 9.672, P = 0.002), suggesting a potential difference in movement patterns of females captured in treatment and control areas before and after fire.

Timing of postburn movements to summer range was similar for females captured in burned and unburned habitat ($F_{1,106} = 0.56$, $P = 0.456$). Mean movements of females from point of origin located after 15 June ranged from 0.2 to 69.3 km ($\bar{x} = 17.8 \pm 2.0$ km [SE]; N = 81). There was no difference in distances moved by females from treatment ($\bar{x} = 15.2 \pm 2.8$ km; N = 36) and control leks ($\bar{x} = 19.9 \pm 2.7$ km; N = 45) ($F_{1,80} = 0.05$, $P = 0.820$) or among years ($F_{2,80} = 0.02$, $P = 0.980$).

DISCUSSION

Sage Grouse populations are migratory or nonmigratory, depending on plant moisture conditions, vegetal cover, and elevation (Dalke et al. 1960, Beck 1975, Wallestad 1975, Connelly 1982, Fischer et al., in press). Connelly et al. (1988) investigated spring and summer movements of migratory Sage Grouse in southeastern Idaho and found that birds moved as far as 82 km, usually as directional movements from breeding and nesting areas to summer ranges. Sage Grouse on our study area used contiguous areas for wintering, breeding, and nesting, but migrated as far as 69 km to summer ranges. This study and that of Robertson (1991) documented seasonal habitats and migration routes for Big Desert Sage Grouse, which is critical information for managing a migratory Sage Grouse population (Berry and Eng 1985, Connelly et al. 1988). We demonstrated that Sage Grouse in the Big Desert primarily migrated northwest to higher elevations near Arco, Idaho (Q-IV), or southwest to lower elevations near Minidoka, Idaho (Q-III). Connelly et al. (1988) captured Sage Grouse

TABLE 1

FREQUENCY OF OCCURRENCE OF FEMALE SAGE GROUSE IN QUADRANTS CENTERED ON POINT-OF-ORIGIN, PREBURN (1987–1989), AND POSTBURN (1990–1992), BIG DESERT, SOUTHEASTERN IDAHO

	Preburn						Postburn					
		Frequency of occurrence[a]				P		Frequency of occurrence				P
	N[b]	Q-I	Q-II	Q-III	Q-IV	H_0: Homogeneity	N	Q-I	Q-II	Q-III	Q-IV	H_0: Homogeneity
01–15 May	75	0.40	0.23	0.15	0.23	0.082	93	0.31	0.23	0.19	0.27	0.420
16–31 May	79	0.28	0.25	0.17	0.30	0.124	57	0.35	0.14	0.21	0.30	0.120
01–14 Jun	63	0.32	0.25	0.19	0.29	0.572	43	0.21	0.19	0.28	0.33	0.560
15–30 Jun	53	0.26	0.21	0.21	0.32	0.568	71	0.24	0.27	0.27	0.23	0.940
01–15 Jul	66	0.12	0.23	0.47	0.24	0.001	31	0.10	0.19	0.58	0.13	0.000
16–31 Jul	52	0.06	0.19	0.52	0.23	0.000	24	0.33	0.00	0.25	0.42	0.025
01 Aug–30 Sep	82	0.02	0.15	0.57	0.26	0.000	14	0.00	0.14	0.36	0.50	0.040

[a] Q-I = 0–90°; Q-II = 90–180°; Q-III = 180–270°; Q-IV = 270–360°.

[b] Number of female Sage Grouse located during each time interval over a 3-year period.

TABLE 2

FREQUENCY OF OCCURRENCE OF FEMALE SAGE GROUSE IN QUADRANTS CENTERED ON POINT-OF-ORIGIN PREBURN (1987–1989), AND POSTBURN (1990–1992) CONTROL AREA, BIG DESERT, SOUTHEASTERN IDAHO

	Preburn						Postburn					
		Frequency of occurrence[a]						Frequency of occurrence				
	N[b]	Q-I	Q-II	Q-III	Q-IV	*P* H_0: Homogeneity	N	Q-I	Q-II	Q-III	Q-IV	*P* H_0: Homogeneity
01–15 May	37	0.41	0.27	0.16	0.16	0.123	53	0.32	0.17	0.23	0.28	0.430
16–31 May	37	0.32	0.35	0.11	0.22	0.141	28	0.39	0.07	0.14	0.39	0.030
01–14 Jun	31	0.39	0.26	0.13	0.23	0.240	25	0.24	0.08	0.32	0.36	0.220
15–30 Jun	25	0.32	0.32	0.12	0.24	0.455	44	0.21	0.23	0.34	0.23	0.580
01–15 Jul	28	0.22	0.29	0.39	0.11	0.220	22	0.05	0.18	0.64	0.14	0.000
16–31 Jul	20	0.10	0.30	0.50	0.10	0.034	10	0.50	0.00	0.20	0.30	0.174
01 Aug–30 Sep	31	0.03	0.26	0.68	0.03	0.000	7	0.00	0.14	0.57	0.29	0.187

[a] Q-I = 0–90°; Q-II = 90–180°; Q-III = 180–270°; Q-IV = 270–360°.

[b] Number of female Sage Grouse located during each time interval over a 3-year period.

TABLE 3

FREQUENCY OF OCCURRENCE OF FEMALE SAGE GROUSE IN QUADRANTS CENTERED ON POINT-OF-ORIGIN, PREBURN (1987–1989), AND POSTBURN (1990–1992) TREATMENT AREA, BIG DESERT, SOUTHEASTERN IDAHO

	Preburn						Postburn					
		Frequency of occurrence[a]				P		Frequency of occurrence				P
	N[b]	Q-I	Q-II	Q-III	Q-IV	H_0: Homogeneity	N	Q-I	Q-II	Q-III	Q-IV	H_0: Homogeneity
01–15 May	38	0.40	0.18	0.13	0.29	0.250	40	0.30	0.30	0.15	0.25	0.490
16–31 May	42	0.24	0.17	0.21	0.38	0.240	29	0.31	0.21	0.28	0.25	0.820
01–14 Jun	32	0.25	0.25	0.25	0.25	0.999	18	0.17	0.33	0.22	0.28	0.770
15–30 Jun	29	0.21	0.14	0.28	0.38	0.310	27	0.30	0.33	0.15	0.22	0.560
01–15 Jul	42	0.05	0.17	0.48	0.31	0.000	9	0.22	0.22	0.44	0.12	0.562
16–31 Jul	32	0.03	0.13	0.53	0.31	0.000	14	0.21	0.00	0.29	0.50	0.072
01 Aug–30 Sep	51	0.02	0.08	0.51	0.39	0.000	7	0.00	0.14	0.14	0.71	0.040

[a] Q-I = 0–90°; Q-II = 90–180°; Q-III = 180–270°; Q-IV = 270–360°.

[b] Number of female Sage Grouse located during each time interval over a 3-year period.

adjacent to our study area that moved to summering areas on irrigated lawns or agricultural fields. Females in our study that moved northwest summered in or near agricultural fields or moved beyond agriculture to natural summer ranges (i.e., mesic mountain valleys). Grouse moving southwest were found primarily in or near agricultural fields but also in mesic meadows near these fields. Traditional migration routes in this direction probably were to the higher foothills and mountain meadows located farther to the west. Similar to Connelly et al.'s (1988) findings, many birds that encounter agriculture remain in or near these fields during summer. Most irrigated agricultural areas now used by Sage Grouse as summer habitats provide abundant lush vegetation where none previously existed. These areas were historically xeric sagebrush habitats that probably were not suitable summer range. However, the effects on females of stopping short of traditional summer ranges to use agricultural areas is unknown. Our findings were consistent with those of Connelly et al. (1988) who concluded that most grouse in the Big Desert use traditional migration routes. To support this contention, grouse on our study area could have moved northeast 15–20 km to irrigated agricultural fields, but significantly fewer grouse than expected moved to these areas during summer.

The hypothesis that fire has no influence on Sage Grouse migration was statistically rejected. The significant Area x P interaction suggested that movements of birds from burned and unburned areas differed before and after fire. However, the main differences in observed movement patterns of females between areas was the higher frequency of postburn females from the control moving northwest and the lower frequency of postburn females from the treatment moving southwest (Q-III). Assigning this statistical difference to a treatment effect is dubious and may be related to sampling effort among quadrants. More extreme departures from preburn migrational patterns, especially for treatment females, would have provided a stronger case for true differences before and after fire. The same migration routes were consistently used disproportionately both pre- and postburn, again providing evidence for the traditional nature of these routes. Because grouse moved up to 69 km from breeding or nesting range to summer range, the burned area within breeding/nesting range represented only a small fraction of the annual range of females captured in the treated area. Habitat fragmentation, resulting from removal of large blocks of sagebrush along traditional migration routes, or in summer range, may influence migratory patterns or distribution of Sage Grouse.

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